High Temperature Materials Laboratory

Providing researchers with the equipment and support to enhance transportation materials technology

ENERGY EFFICIENCY AND RENEWABLE ENERGY

OFFICE OF TRANSPORTATION TECHNOLOGIES

Transportation FOR THE 21ST CENTURY

Advanced materials, including ceramics, composites, and intermetallic compounds, can play an important role in improving the efficiency of transportation engines and vehicles. For example, solid-ceramic or ceramic-coated metal parts can withstand the aggressive environments within today's most efficient and sophisticated engine designs better than metals, thus enabling the development of high-efficiency engines. Similarly, advanced alloys, such as high-strength steels, ordered intermetallic compounds, such as nickel aluminide, and the lightweight metals aluminum, magnesium, and titanium, hold the promise of a new generation of lightweight vehicles. A number of issues, however, including brittleness, proper lubrication, and practical manufacturing and processing procedures need be addressed before the benefits of high-temperature and lightweight materials can be fully realized. While teams of scientists and engineers are actively working to develop solutions to these and other technical barriers, few individual companies and institutions can afford the extensive array of instrumentation needed to test and evaluate high-temperature materials and lubricants.

HTML provides access to state-of-the-art equipment and expertise

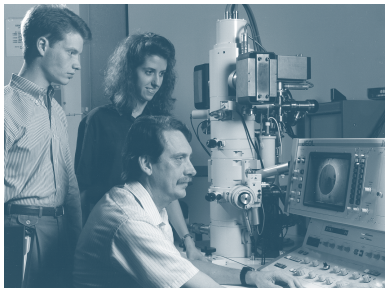
Sponsored by the U.S. Department of Energy's (DOE) Office of Transportation Technologies, the High Temperature Materials Laboratory (HTML), located at Oak Ridge National Laboratory, is a nationally designated user facility dedicated to materials characterization. The mission of the HTML is to help engineers, scientists, and students in U.S.-based organizations solve materials problems of interest to DOE and to advance our knowledge of materials science and technology. The HTML includes six "user centers" which are available to researchers in industry, universities, and Federal laboratories. The user centers contain specialized equipment dedicated to specific types of property measurements. Together, the user centers provide unique capabilities for characterizing the microstructure, microchemistry, physical, and mechanical properties of materials over a wide range of temperatures. The facility assists in the development of materials that must operate at elevated temperatures and/or stresses, such as those found in internal combustion engines, including advanced diesels.

The HTML has two major objectives:

- Conduct research that will assist U.S. industry in meeting challenges from foreign competitors in materials related to transportation.
- Assist in educating and training materials researchers.

The user centers offer a range of materials-characterization capabilities, including electron microscopy and microchemical characterization, crystal structure analysis by X-rays and neutrons, mechanical and thermophysical property measurement, wear testing, and advanced grinding evaluations. Complete tribological characterization is also available, including sliding, rolling, fretting, and impact under conditions of controlled atmosphere and temperature, with or without lubricating fluids present.

The HTML User Program provides researchers from industry and academia access to state-of-the-art equipment and facilities to solve materials-related problems. Most, but not all, projects involve materials primarily related to the transportation industry. Both nonproprietary and proprietary research can be performed with the former provided free of charge if the user publishes the information produced. For proprietary research, the user agrees to pay an hourly rate for access to the equipment and staff. These projects typically are more extensive than nonproprietary projects, and the user owns the data from the research. As of the end of fiscal 1999, after 12 full years of operation, nearly 500 user agreements were in place resulting in 900



HTML staff members work with one of the field-emission gun scanning electron microscopes to image the fracture surface of a fiber from a ceramic matrix composite material.

approved research proposals in various stages of completion. These proposals have involved several hundred individual users performing research in the HTML. Industrial users range from the very small (companies with fewer than 20 people) to the very large (e.g., Cummins Engine Company, Caterpillar Inc., and Detroit Diesel Corporation.) Projects have included efforts to improve diesel fuel injector components by testing materials, such as surface-modified alloys, coatings on metals, and monolithic ceramics. Other research has included the development of machining technologies, performing tribological characterizations and nanohardness measurements on thin film coatings, and residual stress analyses on fuel injection and other components.

The User Centers

The HTML houses six "user centers," which are clusters of specialized equipment designed for specific types of properties measurements:

Materials Analysis User Center (MAUC)
Researchers in the MAUC employ electron microscopy and surface chemical analysis to determine structure, surface chemistry, and microstructure to the atomic level. Advanced microscopy capabilities allow rapid, direct elemental analysis of grain boundaries in metals and ceramics. A new scanning Auger nanoprobe is available for analyzing material surfaces.

Mechanical Characterization and Analysis User Center (MCAUC)
MCAUC researchers study fracture toughness, tensile strength, flexure strength, and tensile creep of advanced materials at temperatures to 1500°C in air or controlled atmospheres. Special instrumentation is available for studying fiber-matrix interactions in both metal and ceramic matrix composites.

Residual Stress User Center (RSUC)
The RSUC has two principal parts: X-ray diffraction and neutron diffraction. The X-ray portion includes X-ray diffractometers to measure residual stress and texture in and near the surface of ceramics and alloys. A synchrotron beamline is also available to help solve special problems requiring high intensity, small spot-size x-ray beams. The neutron residual stress facility includes a special neutron spectrometer for rapid data collection, allowing measurement of stresses in thick sections, such as engine blocks.

Diffraction User Center (DUC)
The DUC has room-temperature and furnace-equipped x-ray, synchrotron, and neutron diffractometers. The x-ray furnace is used to study material properties at temperatures up to 2700°C in vacuum and up to 1500°C in air.

Thermophysical Properties User Center (TPUC)
TPUC researchers study thermal stability, expansion, and thermal conductivity of materials to 1400°C. A laser flash instrument measures thermal diffusivity to temperatures of 1900°C. The center also possesses a high-speed, high-sensitivity infrared camera for capturing thermal events digitally, allowing on-line measurement of temperatures during rapid transient events.

Machining and Inspection Research User Center (MIRUC)
This center employs instrumented surface and cylindrical grinders to study hard material grinding on ceramics and special alloys. These dynamometer-equipped machine tools provide unique capabilities for studying grinding forces and their roles in controlling the topography and mechanical and wear properties of the resulting surfaces. Other capabilities include instruments for determining the cylindricity and circularity of axially symmetric objects, and equipment for measuring friction and wear, including fretting, rolling, and sliding.

In addition to providing this wide range of instrumentation, HTML's User Centers are designed to be "user friendly." Technical experts are available to provide on-site assistance to their private sector colleagues in the use of the equipment, and where needed, even help to analyze and interpret results. Convenient office space and other amenities are also provided to visiting researchers performing longer-term investigations. To learn more about the High Temperature Materials Laboratory, please visit our Web site at http://www.ms.ornl.gov/htmlhome.

For more information on how DOE is helping America remain competitive in the 21st century, please contact:

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